OPEN IT TOOLS FOR AN INQUIRY-BASED PHYSICS EDUCATION

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INTRODUCTION

In case of inquiry-based education, the priority is the pupil's activity, developing his/her practical and research skills. We can use the knowledge and skills obtained by the pupil from other subjects. Applied informatics into physics seems to be a suitable application of digital literacy. Open IT tools are the ones of the available IT tools that bring several benefits to promote freedom of inquiry.

An overview of open IT tools for physics education includes microprocessor kits with a variety of analog and digital electronic components, a large number of application software, simulation software, programming languages, libraries and development environments, web tools, virtual laboratories, data catalogs, hypertext documents and other auxiliary resources. Such open IT tools together with suitable open educational resources will be applicable in physics, mathematics, informatics and other subjects.

INQUIRY-BASED PHYSICS EDUCATION

Physics is a natural science subject that forms the natural or technical thinking of the pupil. The key to the success of teaching physics is the motivation of the pupil. Inquiry-based learning simulates the work of a scientist in exploring, discovering, researching. Inquiry-based education fits best on natural science subjects, including physics, because natural sciences are the discovering sciences. Research teaching is an activation method where the pupil is active and the teacher accompanies him. Inquiry-based learning is derived initially from constructivism, self-creation of a problem/ task solution and also from constructionism, self-formation of knowledge. The pupil is naturally curious.

Inquiry-based education can be realized at several levels of inquiry [1]:

- Interactive demonstration
- Exploration (verification, confirmation)
- Directed inquiry (instructed experimentation)
- Guided inquiry (teacher assigns the task)
- Open inquiry (pupil assigns the task)

APPLIED INFORMATICS INTO PHYSICS

Informatics as a school subject should be a mix of all major fields of study: computer engineering, computer science, data science. Physics, together with mathematics, gives informatics a science base (computer science) and a technical base (computer engineering). Applied informatics in theoretical and experimental physics is the engine of research and development. Applied informatics (digital skills, programming and data science) in physics can be a new trend in didactics of physics that could increase pupils' motivation and practical use of knowledge and skills.

Open tools are suitable in the inquiry-based education. Openness, expressed in an appropriate public license, gives the user the right to use the tool for any purpose – for example, to explore something with the tool, to explore how the tool works, to modify the tool. This is the freedom of inquiry. The low price of the open tool is also a significant factor.

Teamwork is an important part of inquiry-based education. That's why we also need collaborative IT tools.

MICROPROCESSOR KITS

We usually call a group of science and technology subjects as STEM (science, technology, engineering, mathematics). Various practical STEM activities in a classroom use hands-on approach. [2] Microprocessor kits are suitable tools for the interleaving of physics and informatics. These kits consist of a small printed circuit board with a microprocessor/microcontroller and a set of various electronic components.

The best-known open source hardware kits are: BBC micro:bit, Arduino, Raspberry Pi with a galore of all similar products. BBC micro:bit (fig. 1) is an inexpensive 8/16/32-bit microcontroller with a set of sensors and LEDs, especially suitable for primary schools.

Fig. 1. BBC micro:bit

Arduino (fig. 2) is an 8/16/32-bit minicomputer with analog and digital I/O. Arduino kit contains a set of external electronic components, extensions or add-ons.

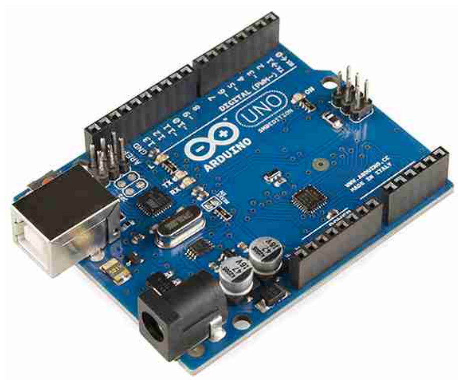

Fig. 2. Arduino

Raspberry Pi (fig. 3) is a 64-bit computer with a full operating system (GNU/Linux).

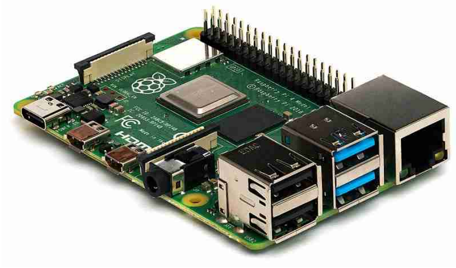

Fig. 3. Raspberry Pi

Arduino and Raspberry Pi are suitable mostly for secondary schools. Some microprocessor kits could be interconnected to form more complex configurations.

OPEN SOURCE SOFTWARE, FREE SOFTWARE

Public-funded schools should preferably use open source software / free software for education and for operation. Open source software is easily portable to different operating systems and different hardware.

GNU/Linux is a famous open source operating system. This software offers several attractive graphical user interfaces, a command line (bash) that is a versatile efficient tool for processing text and numeric data and for scripting. CERN/Fermilab Scientific Linux is a special operating system distribution designed for scientists.

Android, the Linux-based most popular operating system for smartphones and tablets, is easily accessible to pupils and teachers. There are many Android applications using computer sensors. We can find interesting guides for inquiry-based learning with Android devices in the classroom on the web. [3]

Algodoo is an application for simple physical animations. Tracker makes visualization and motion analysis. EJS (Easy Java/JavaScript Simulations) helps non-programmers create interactive simulations in Java or JavaScript, mainly for teaching or learning purposes.

Popular programming environments for younger pupils: Scratch, MIT App Inventor. Programming languages suitable for education and science: Python, PHP, JavaScript, C/C++, Java and others. Languages for data storing, processing and presentation: SQL, HTML/ XHTML with CSS, XML, JSON.

Geogebra is easy-to-use mathematical application for pupils. Gnuplot is a useful tool for visualizing numeric data. Powerful mathematical software, programming languages or libraries: Scilab, Octave, Yacas, Maxima, SciPy, R, SageMath, GDL etc. KNIME is a data analytics, reporting and integration platform.

LibreCAD and QCAD are 2D technical charts editors. KiCad, ngspice, logisim are applications for electronics.

Finally common applications: Mozilla Firefox browser, LibreOffice suite including Calc spreadsheet.

WEB TOOLS

We need collaborative tools in inquiry-based education [4], preferably web tools. Etherpad is an easy text editor. We can be inspired by programmers who use complex collaborative tools: Slack, Git.

Didactically processed educational content is provided by interactive web games, interactive web-based educational applications, open courses (MOOC).

Wikipedia, free online encyclopedia, is probably the first choice when looking for expert information. Wikidata acts as central storage for the structured data of projects including Wikipedia and others, can be used also as a data source for school topics.

Wolfram Alpha is a computational knowledge engine, very interesting for pupils and teachers.

VIRTUAL LABORATORIES

If the school does not have a real laboratory, it can use a virtual laboratory. Watching video of some experiment is the simplest form. ASPIRE Lab provides a simulated laboratory, similar to real scientific simulations. Computer virtualization allows you to run a software environment with the required parameters for computer-based experiments. Controlled remote experiment is a typical scientific method, which is also useful in the education. Virtual observatory is a special virtual laboratory, mainly for astronomy and astrophysics, such as EURO-VO project. Some software tips: Stellarium (virtual planetarium), Celestia (interactive space simulator), Aladin (interactive space atlas with data processing and visualization).

CONCLUSIONS

Inquiry-based learning increases pupil's motivation through attractive observations and experiments, and develops practical and research skills. Applied informatics in physics is probably an effective way of applying digital literacy to physical thinking. Open IT tools bring benefits and promote freedom of inquiry.

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FIGURE REFERENCES

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